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Integral equation methods in optical waveguide theory

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Abstract

The eigenvalue problems for generalized natural modes of an inhomogeneous dielectric waveguide without a sharp boundary and a step-index dielectric waveguide with smooth boundary of cross-section are formulated as problems for the set of time-harmonic Maxwell equations with partial radiation conditions (Sveshnikov radiation conditions) at infinity in the crosssectional plane. The original problems by integral equations method are reduced to nonlinear spectral problems with Fredholm integral operators. Theorems on spectrum localization are proved, and then it is proved that the sets of all eigenvalues of the original problems can only be some sets of isolated points on the Reimann surface, ant it also proved that each eigenvalue depends continuously on the frequency and dielectric permittivity and can appear and disappear only at the boundary of the Reimann surface. The Galerkin method for numerical calculations of the generalized natural modes are proposed, and the convergence of the method is proved. Some results of numerical experiments are discussed.